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(71) Applicant
Comitato Nazionale per La Ricerca e Per Lo Sviluppo Dell Energia Nucleare e Delle Energie Alternative ENEA
(Italy)
125 Viale Regina Margherita
I-00198 Rome
Italy
(72) Inventors
Giuliano Sciocchetti
Franco Scacco
(74) Agents
Stanley Popplewell
Poole
57 Lincoln's Inn Fields
London WC2A 3LS

(54) Monitoring radon and thoron daughters

(57) An apparatus for measuring the RaA, RaB, RaC, RaC', ThA, ThC, ThC' individual concentrations in air samples comprises a sampling head 50 wherein a chamber is defined which is divided in two parts 32, 36 by a flat filter medium which faces a radiation detector 30.

The part 36 is connectable to the enviroment to be sampled through a shut-off valve 38, while portion 32 is connectable to a vacuum pump through a second shut-off valve. Detector 30 is connected to a multi-channel analyzer of the alpha particles of different energy emitted by the radon daughters and the thoron daughters, whereby the concentration of these nuclides is determined. Air is filtered through the filter and chamber 36, 32 then evacuated by shutting valve 38 to allow spectrometric counting of nuclide concentrations without the need to transfer the filter to a separate vacuum apparatus. Detector 30 is a silicon surface barrier solid state detector.

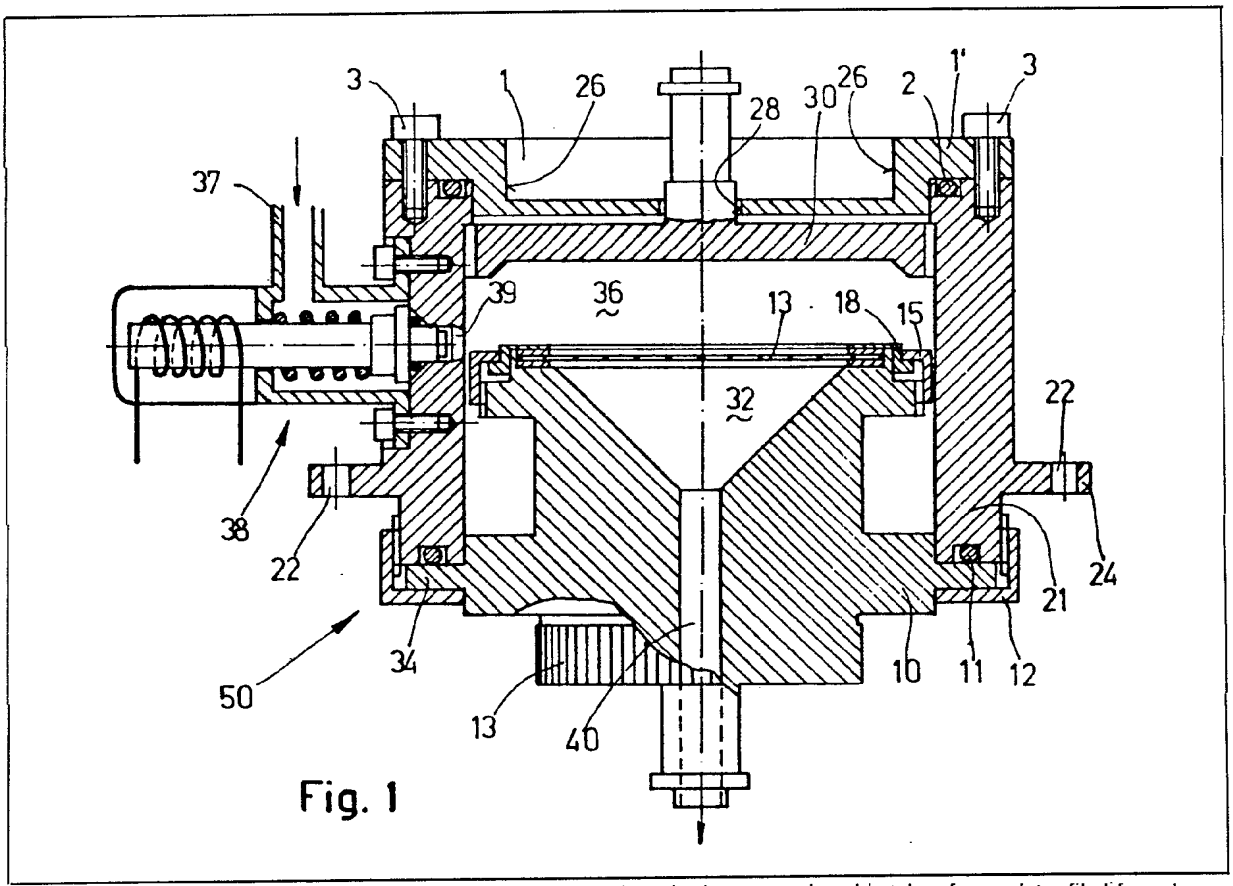

Fig. 1

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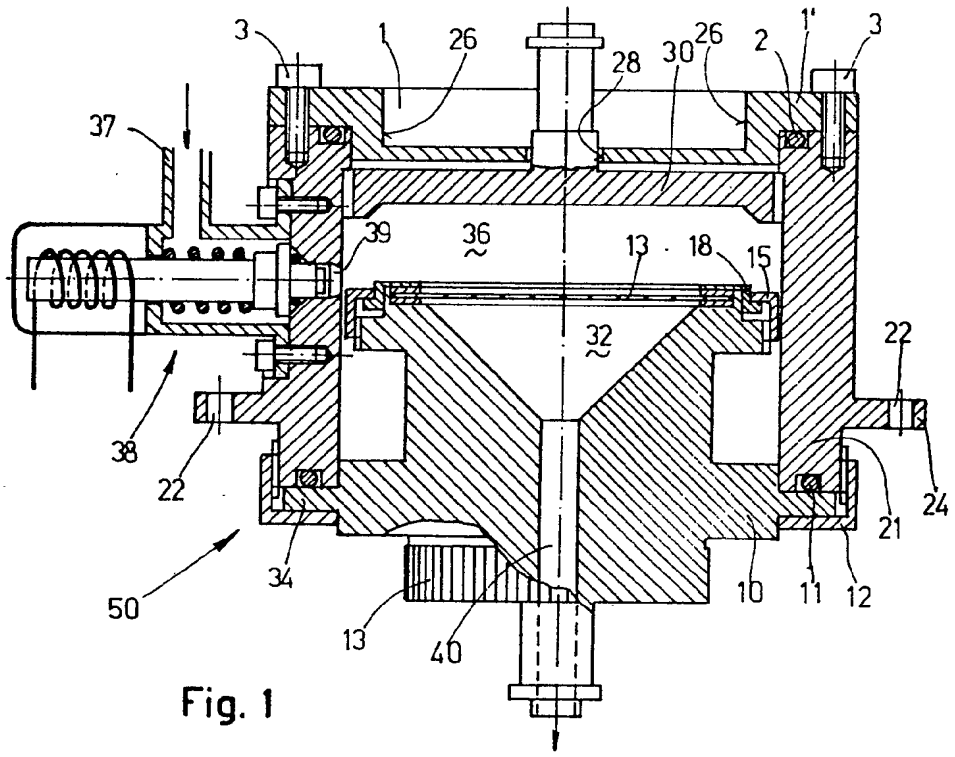

3
1
26
28
30
26
2
1'
3
37
39
36
13
18
15
32
22
38
22
24
21
50
34
10
11
12
13
40

Fig. 1

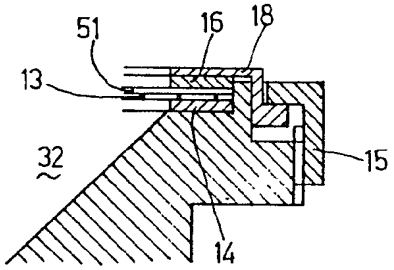
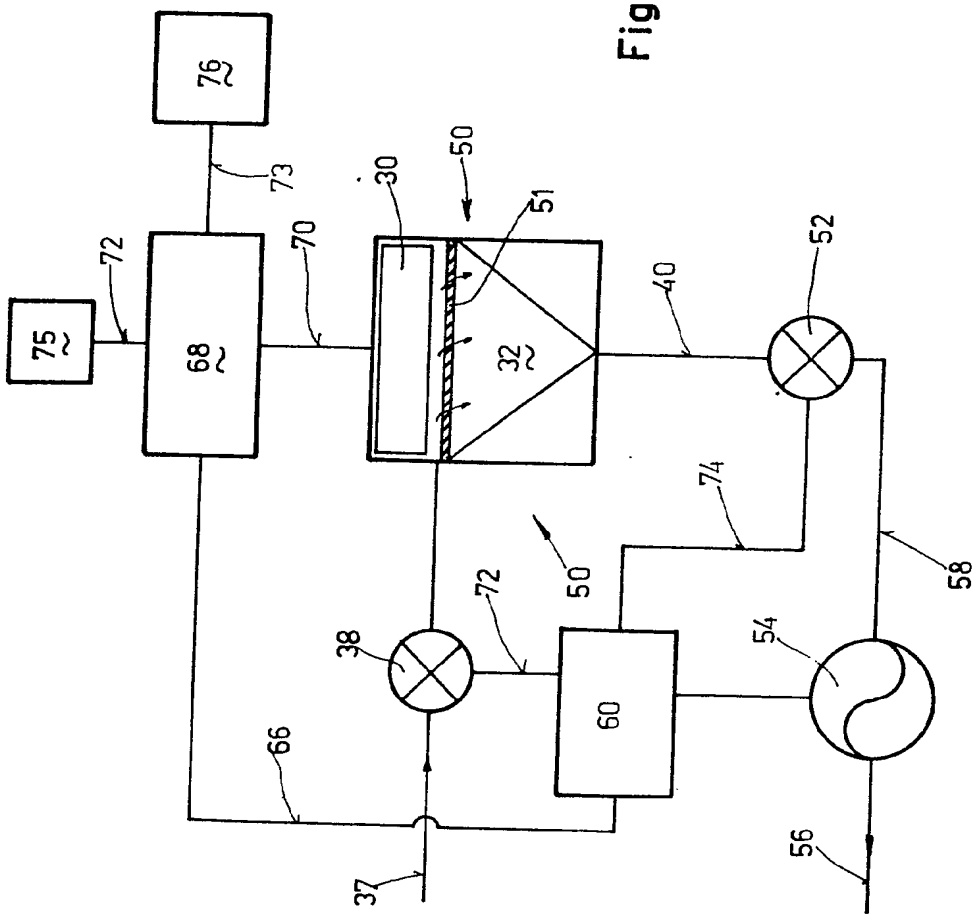
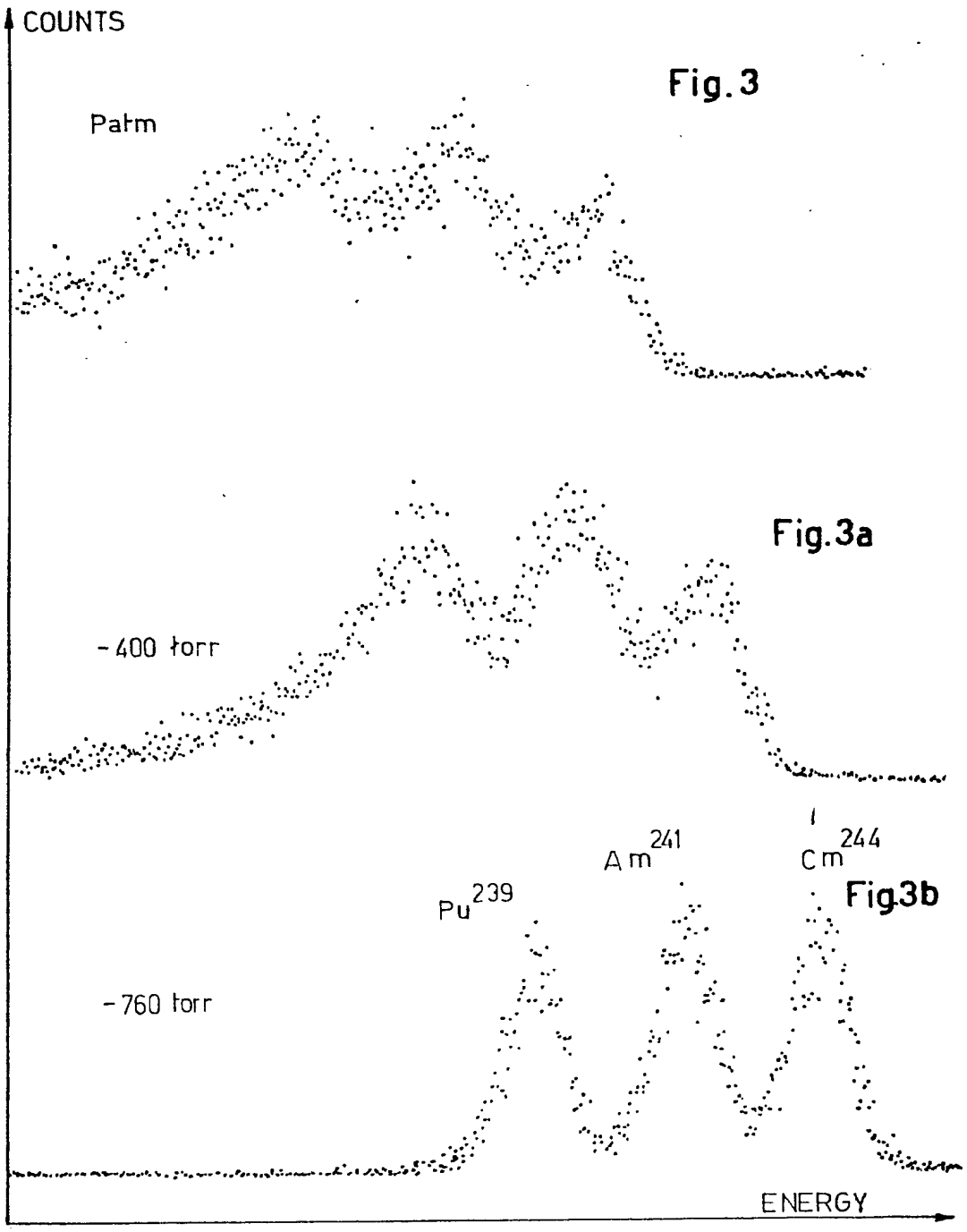

51
16
18
13
32
15
14

Fig. 1a

Fig. 2




COUNTS
Patm
Fig. 3
Fig.3a
-400 torr
Am 241
Cm 244
Pu 239
Fig.3b
-760 torr
ENERGY

SPECIFICATION

Apparatus for rapid monitoring of radon and thoron daughters

The importance of measuring radio-nuclide concentrations either natural or man-produced is growing constantly not only for complying with the health regulations for example in radioactive mines and bathing establishments, but also for checking the exposure to radioactivity in dwellings and in the natural open air enviroment. The measurement of the concentrations of radon daughters and of thoron daughters in free atmosphere is of particular concern. An object of this invention is to provide a portable apparatus for carrying out such measurements speedily and at the same time accurately.

The radioactive decay products of the Rn and Th daughters comprise alpha particles of different energies. The following are the alpha emitting atoms;

Po-218 (RaA) – 6.00 Mev.	Radon daughters
Po-214 (RaC') – 7.69 Mev.	
PO-216 (ThA)	Thoron daughters
Po-212 (ThC) – 6.05 Mev.	
Po-212 (ThC') – 8.78Mev.	

Various methods are presently followed for determining the concentrations of radon and thoron daughters in air, which methods all include the initial step or preparing a sample on which the count of the alpha particles is subsequently carried out.

In such an initial step, enviroment air is drawn in through a filtering medium adapted to retain the radio nuclides.

In the second step the alpha particles are counted. This counting of the alpha particles may be a total counting, that is the counting of the total alpha activity of the filter, wherefrom the potential alpha energy can be obtained, or a spectrometric method whereby the spectrum of the sample being measured can be obtained and thence the individual count of the different energy particles.

Of the above two methods, the total count is more rapidly and readily performed, the more because apparatus has recently been developed by which both the sampling and the particle counting can be made with the help of a filter-facing detector (Nuclear Safety Vol 13 No. 4 July/Aug. 1972). In order to achieve an acceptable resolution of the different energy particles by the spectrometric method, the counting of the alpha particles should be carried out under vacuum and consequently two separate pieces of apparatus are required: one for the sampling and one for the counting operations.

The transfer of the sample from the sampling apparatus to the counting apparatus is also implied. The spectrometric method is then hardly practicable for field measurements at different sites, that is by the use of portable apparatus, so that the total counting method is preferred in such instances.

However it is generally agreed that a greater accuracy can be attained in determining the concentrations of the radon and thoron daughters, and consequently of the working level (WL) by the spectroscopic separation of the different energy particle counts.

Furthermore, the spectroscopic method has the advantage, over the total counting method, of yielding directly with great rapidity and precision individual concentrations in air of the various radionuclides whereby the investigation is obviously facilitated.

However, in order to achieve an acceptable resolution between the different energy particles with the spectrometric methods, the counting of the alpha particles should be made under vacuum. These methods are therefore too laborious for field measurements, for instance in the various dwellings of a given site.

This invention is aimed to combine together the advantages of the spectroscopic methods, that is a great precision of measurement, with the advantage of the total counting method, that is a speedier and an easier measurement.

The present invention provides apparatus for determining the individual concentrations in air of Radon and Thoron daughters, which apparatus comprises a sampler head wherein an airtight chamber is provided which chamber is divided in two portions by a flat filter medium facing towards a radiation detector; a first portion of said chamber being defined between said filter medium and said radiation detector and being connectable to the environment to be sampled; the second portion of the chamber being connectable to a vacuum pump, characterized by a shut-off valve provided between said first portion of said chamber and the enviroment to be sampled and that said radiation detector facing towards said filter medium is a silicon surface barrier solid state detector which is connected to a multichannel analyzer of the different energy particles, that is a spectrometric analyzer.

According to the invention, an apparatus has been therefore developed whereby a sample is first caught on the filter and then the individual counting of the alpha particles of different energy is carried out, that is the spectrum of the measured sample is obtained. The vacuum degree as required for obtaining an acceptable resolution between the particles of different energy is obtained by the same pump by which the air to be analyzed is drawn in through the filter. In fact, as found by the inventors, an acceptable resolution can be achieved also under a limited vacuum, as will be shown hereinafter.

It is therefore the main object of this invention to provide an apparatus for determining

the individual concentrations in air of the radon and thoron daughters by the spectrometric method which apparatus is compact, light and portable.

A further object of this invention is to provide an apparatus adapted for determining the concentration in air of the radon and thoron daughters wherein the filter medium with the caught nuclides needs not to be removed from its seat in order to count the alpha particles emitted by them.

Additional objects and advantages of the apparatus of this invention will appear from the following description and attached drawings of a preferred embodiment of the invention, in which drawings:

Figure 1 shows an axial cross section of a sampling head of an apparatus according to this invention;

Figure 1a shows an enlarged detail of Fig. 1;

Figure 2 is an operational block diagram of the apparatus according to the invention;

Figures 3, 3a, 3b are graphs which illustrate three alpha spectra obtained respectively at atmospheric pressure, and at two different degrees of vacuum.

Fig. 1 shows a sampling head comprising a hollow cylindrical body 21 mounted on an apparatus casing—not shown—by means of bolts inserted through holes 22 of flange 24 of the body 21.

One end—the lower end in Fig. 1—of cylindrical body 21 is closed by a circular cover 1 provided with a flange 1′ which engages an end surface of the body wall with the interposition of an 0-ring seal 2. Cover 1 is recessed at its outer surface to reduce the weight purposes and is forced against the cylinder 21 by a row of screws 3. Underneath cover 1 a solid state detector 30 is mounted, the BNC connector 31 of which traverses the cover plate 1 through a bore of which is provided at the centre thereof. Detector 30 may be a silicon barrier detector.

A filter holder 10 is received through the other end of body 21 which holder comprises a solid cylinder whose diameter, over a short section thereof, is the same as the inner diameter of cylinder 21. A circular flange 34 projects from said short section at the level of the lower end of cylinder 21 which flange engages the front surface of the lower end of cylinder 21 with the interposition of an 0-ring seal.

Ready replacement of the filter without any need for dissassembling the filter holder from the sampling head is allowed by the above coupling of the filter holder 10 with cylinder 21.

Next to said short section upwards, the diameter of filter holder 10 is reduced to decrease weight and then it becomes larger again, although again smaller then the inner diameter of cylinder 21. Filter holder 10, at its end facing the detector, has a funnellike recess 32 the mouth of which is surrounded by a circular ledge forming a seat for a stainless steel net 13 in whose side facing the detector a filter is seated which may be, for instance, a multipore filter 51 with 0.45 pores.

A gasket 14, 14 is provided on top of the filter rim and under the net rim respectively. A circular ring 18 with Z cross section is provided for retaining net 13, filter 51, and gasket 14, 14 which ring is forced downwardly by a locking ring 15 threadingly engaged with filter holder 10.

Filter holder 10 at its end opposite to detector 30 is provided with a knurled circular projection 13 as a means for handling the head assembly and for withdrawing the filter holder from the cylindrical body 21.

It is to be noted that because filter holder 10 is coupled to cylindrical body 21 by means of locking ring 12, the sampling head 50 of this invention lends itself to ready calibration of the apparatus in as much as the filter holder can be easily replaced with a source holder.

Furthermore it clearly appears from the configuration of this sampling head that the filter 51 can be readily replaced without removing detector 30 from the same head.

Within detector 30, filter 51 and the wall of cylindrical body 21 a cylindrical chamber 36 is defined into which the air to be analyzed is fed. After passing through filter 51 the air is discharged through duct 40 which axially traverses the filter holder 10. The air to be analyzed is drawn in through inlet 37, power operated valve 38, and intake port 39 in the wall of the cylinder 21 which port is alternately closed and opened by said power operated valve 38 whose solenoid is included in the circuit of a programmable timer to be described hereinafter.

Sampling head 51 is included in the apparatus shown schematically in Fig, 2. With reference to Fig. 2, such apparatus comprises head 50 along with the related filter 51 the head being connected to valve 38. A second power operated valve is connected to discharge duct 40 and to vacuum pump 54 through line 58. The final air exhaust is through line 56. The solenoids of power operated valves 38 and 52 are connected through the respective lines 72 and 74 to a programmable timer 60 which, through line 66, controls also a multichannel spectrometric analyzer 68, the latter being connected to detector 30 through line 70. Analyzer 68 connects to a high voltage feeder 75 through line 72 and to a data display 76 through line 73.

With valves 38 and 52 open, pump 54 is started and by means of a flow meter—not shown—the air flow through filter 51 is measured and recorded unitl a predetermined volume of air has been drawn through the sampl-

ing head.

Valve 38 is then shut off while keeping valve 52 open until the maximum vacuum obtainable by the pump is set up within the sampling head. Valve 52 is then shut and pump 54 is stopped. The degree of vacuum thus obtained obviously depends on the pump performance and on the volume of chamber 36.

Some tests have been carried out with the apparatus of this invention in which a portable membrane pump available on the market was used. Although the maximum attainable vacuum was only in the range from—100 to 200 torr, a spectrometric measurement could be carried out and with good results.

Obviously the resolution depends on the degree of vacuum, as is evidenced by the graphs of Figs. 3a, 3b and 3c which illustrate three alpha spectra at different vacuum degrees.

Fig. 3a–at atmospheric pressure
Fig. 3b–at – 400 torr
Fig. 3c–at – 760 torr.

As shown by Fig. 3b, the resolution at 400 torr is such that the spectrometry methods can be applied for measuring the Radon daughters by the use of a portable apparatus.

From the above, the great advantage of the sampler of this invention becomes apparent whereby the counting of the filter can be carried out under vacuum—although not under a high vacuum—and thus a high resolution spectrometry method can be applied without any need for removing the filter from the sampler or in anyway manipulating it.

It is also apparent that the apparatus of this invention lends itself to calibration by means of standard radioactive atmosphere, in as much as the inlet 37 can be connected to a bubbler in which contains a solution of Ra-226 which is a radioactive isotope progenitor of Radon.

CLAIMS

1. Apparatus for determining the individual concentrations in air of Radon and Thoron daughters, which apparatus comprises a sampler head wherein an airtight chamber is provided, which chamber is divided in two portions by a flat filter medium facing towards a radiation detector; a first portion of said chamber being defined between said filter medium and said radiation detector and being connectable to the environment to be sampled; the second portion of the chamber being connectable to a vacuum pump, characterized by a shut-off valve provided between said first portion of said chamber and the enviroment to be sampled and that said radiation detector facing towards said filter medium is a silicon surface barrier solid state detector which is connected to a multichannel analyzer of the different energy particles, that is a spectrometric analyzer.

2. Apparatus as claimed in claim 1, wherein the detector is specific to alpha and beta radiations.

3. Apparatus as claimed in claim 1 or 2, wherein the filter medium is seated on top of a cylindrical filter holder and coupled thereto in fluid tight manner by means of a first locking ring threadingly engaged with an upper outer portion of said cylindrical filter holder; said filter holder being fitted into a hollow cylindrical body and coupled thereto by means of a second locking ring threadingly engaged with the outer surface of said hollow cylindrical body, which second locking ring forces a flange of said filter holder against the end surface of said hollow cylindrical body; said filter holder being provided at its end opposite to the filter seat with a knurled knob.

4. Apparatus as claimed in claim 1, 2 or 3, wherein a shut-off valve is connected between said chamber of the sampler head and the vacuum pump.

5. Apparatus as claimed in any one of claims 1 to 4 wherein said shut-off valve or valves is/are electrically controlled through a programmable timer.

6. A detector head for a radionuclide concentration detector, comprising a chamber having a filter mounted therein, the chamber having an inlet to atmosphere and an outlet to pump means for drawing air through the filter, means for sealing the inlet to create a vacuum in the chamber on continued pump operation, and a detector within the chamber to distinguishably detect radiation of different energies.

7. Apparatus for determining the individual concentrations in air of Radon and Thoron daughters, substantially as hereinbefore described with reference to the accompanying drawings.

8. The features hereinbefore disclosed or their equivalents in any novel combination.

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